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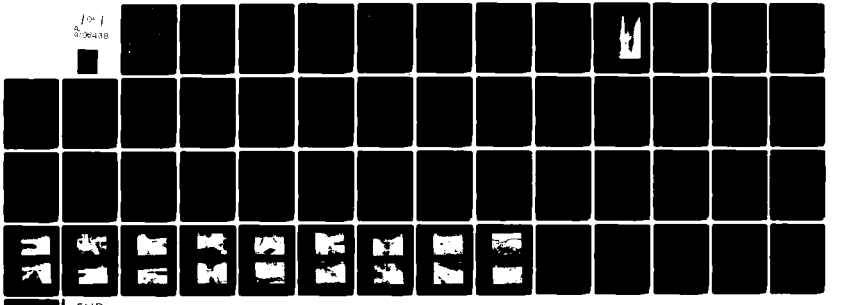

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WINNETONKA LAKE DAM

CLAY COUNTY, MISSOURI

MO 11011

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

APRIL 1979

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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MISSOURI-KANSAS CITY BASIN

WINNETONKA LAKE DAM

CLAY COUNTY, MISSOURI

MO 11011

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

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PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

APRIL 1979

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Winnetonka Lake Dam (Mo. 11011)

This report presents the results of field inspection and evaluation of Winnetonka Lake Dam (Mo. 11011).

It was prepared under the National Program of Inspection of *Non-Federal Dams*.

This dam has been classified as unsafe, non-emergency because of severe erosion under the abandoned spillway and the concrete chute spillway, the unprotected excavated trench and erosion of the embankment at the trench, previous embankment failures which have been temporarily repaired, sloughing on the upstream and downstream embankment slopes, the presence of excessive brush and tree growth on the embankment slopes, and seriously inadequate spillways which will pass only 20 percent of the probable maximum flood.

Because of the extent and severity of deficiencies, it is recommended that remedial measures be undertaken as soon as possible to insure the safety of this dam.

SUBMITTED BY: SIGNED — 30 JUL 1979
Chief, Engineering Division — Date

APPROVED BY: SIGNED — 30 JUL 1979
Colonel, CE, District Engineer — Date

WINNETONKA LAKE DAM

CLAY COUNTY, MISSOURI

MISSOURI INVENTORY NO. 11011

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

APRIL 1979

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Winnetonka Lake Dam
State Located	Missouri
County Located	Clay County
Stream	Tributary to Buckeye Creek
Date of Inspection	10 April 1979

Winnetonka Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers failure would threaten the life and property of four families downstream of the dam and would potentially cause appreciable damage to an elementary school, State Highway 269, and the Chouteau Trafficway within the estimated damage zone which extends 1 mile downstream of the dam. Commercial developments in proximity to Highway 269 were observed at the time of inspection.

Our inspection and evaluation indicates the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway and trench will not pass the probable maximum flood without overtopping but will pass 20 percent of the probable maximum flood, which is greater than the 100-year flood. The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the volume of water impounded and the downstream hazard, 50 percent of the probable maximum flood is the appropriate spillway design flood. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Deficiencies visually observed by the inspection team were severe erosion, absence of adequate slope protection, previous embankment failures which have been temporarily repaired, absence of channel protection

in an excavated trench at the east abutment, sloughing of the upstream and downstream embankment, erosion of the discharge channel, undercutting of the spillway and downstream toe of the embankment, and the presence of excessive brush and trees on the embankment slopes. Seepage and stability analyses required by the guidelines were not available.

There were deficiencies and conditions existing at the time of the inspection which raised questions concerning the safety of this structure. Notification of potentially hazardous conditions existing at the Winnetonka Lake Dam was given to the St. Louis District, Corps of Engineers on 11 April 1979. Subsequent to notification of the conditions at the dam site, it was reported that officials from the State of Missouri and Kansas City District, Corps of Engineers inspected this structure. Immediate corrective action and future regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.

On June 18, 1979 under direction of the City of Kansas City, the dam was breached by excavating an opening through the dam at the spillway. The water level in the lake was lowered to elevation 813 by draining the lake through the box culvert under Chouteau Trafficway.

The ownership of Winnetonka has changed hands since the April 10, 1979 inspection. The new owner is Mr. David H. Johnson who can be contacted c/o Farley & Johnson, P.O. Box 33, Farley, Missouri 64028, phone (816) 546-3320.

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OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
WINNETONKA LAKE DAM

TABLE OF CONTENTS

Paragraph No.	Title	Page No.
	SECTION 1 - PROJECT INFORMATION	
1.1	General	1
1.2	Description of Project	1
1.3	Pertinent Data	3
	SECTION 2 - ENGINEERING DATA	
2.1	Design	6
2.2	Construction	6
2.3	Operation	6
2.4	Geology	6
2.5	Evaluation	6
	SECTION 3 - VISUAL INSPECTION	
3.1	Findings	7
3.2	Evaluation	8
	SECTION 4 - OPERATIONAL PROCEDURES	
4.1	Procedures	10
4.2	Maintenance of Dam	10
4.3	Maintenance of Operating Facilities	10
4.4	Description of Any Warning System in Effect	10
4.5	Evaluation	10
	SECTION 5 - HYDRAULIC/HYDROLOGIC	
5.1	Evaluation of Features	12
	SECTION 6 - STRUCTURAL STABILITY	
6.1	Evaluation of Structural Stability	14
	SECTION 7 - ASSESSMENT/REMEDIAL MEASURES	
7.1	Dam Assessment	15
7.2	Remedial Measures	16

LIST OF PLATES

Plate No.	Title
1	Location Map
2	Vicinity Topography
3	Plan
4	Typical Section
5	Spillway Sections
6	Photo Index

LIST OF PHOTOGRAPHS

Photo No.	Title
1	Upstream Face of Dam near West Abutment
2	Crest of Dam near West Abutment
3	Downstream Slope of Dam near West Abutment
4	Upstream Face of Dam Looking East
5	Crest of Dam Looking West
6	Spillway Looking Upstream from Crest
7	Spillway Looking Downstream from Crest
8	Spillway Chute
9	Culvert under Chouteau Trafficway below Spillway
10	Channel below Chouteau Trafficway
11	Downstream Channel
12	Ditch at East Abutment Looking Upstream

LIST OF PHOTOGRAPHS

Photo No.	Title
13	Ditch at East Abutment Looking Downstream
14	Undermining of Spillway at Top of Downstream Slope
15	Undermining of Abandoned Spillway at Downstream Slope
16	Sinkhole in Upstream Face of Dam
17	Sinkhole in Upstream Face and Erosion of Crest
18	Erosion of Downstream Slope

APPENDIX

Appendix A - Hydrologic Computations

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Winnetonka Lake Dam, locally known as Winnwood Lake, be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The Winnetonka Lake Dam is an earth structure located in a tributary valley to Buckeye Creek in southwestern Clay County, Missouri (Plate 1). The dam, according to the owner, was at one time a street right-of-way and formed a lake which early in its history was an amusement park attraction. Evidence of this remains in the form of what appears to be either streetlight foundations or the remnants of an aerial trolley ride at the earlier amusement park. At numerous locations along the downstream edge of the crest there were visible sections of what apparently is a 6 to 8 inch thick concrete wall. Substantiation of a concrete cutoff wall was not made. It may in fact be simply a footing and short curb wall for the previously mentioned street or amusement park appurtenance. The emergency spillway for this structure is a concrete chute with a short earth approach. The freeboard above the crest of the spillway section is minimal. There was no principal spillway observed at this dam. According to the Kansas City District, Corps of Engineers, a previous threat of overtopping and possible failure resulted in city and Corps of Engineers officials excavating a trench through the embankment near the left abutment to effectively reduce the water surface elevation and thereby increasing the surcharge storage capacity.

Interstate 35 bisects the pool formed by this dam. A 6 foot by 7 foot box culvert is located under the Interstate highway to allow for passage of water. A 24-inch reinforced concrete culvert is located beneath the embankment for Interstate 35 and serves as a discharge outlet for the upper pool. The culvert discharges to the pool of Lake Winnetonka south of Interstate 35.

The dam is overgrown with trees and brush. Either apparent seepage or inadequate drainage in an area between the dam and the Chouteau Trafficway has resulted in a relatively large swampy area.

(2) A concrete chute spillway was constructed near the right abutment which discharges to a box culvert beneath the Chouteau Trafficway.

(3) An 8-inch diameter pipe with valve is located beneath the chute spillway crest. The Kansas City District, Corps of Engineers noted that the valve was inoperable.

(4) An excavated trench, for purposes of lowering the lake level, is located at the left abutment.

(5) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in southwestern Clay County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for North Kansas City, Missouri-Kansas in Section 6 of T50N, R32W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Winnetonka Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Winnetonka Lake Dam the estimated flood damage zone extends downstream for 1 mile. Within the damage zone are four homes, commercial buildings, State Highway 269, Chouteau Trafficway, and an elementary school. At the time of inspection it was observed that more than four homes were located in the damage zone.

e. Ownership. The dam is owned by Mr. R. G. Young, 4420 Winn Road, Kansas City, Missouri 64119.

f. Purpose of Dam. The dam forms a 10-acre recreational lake.

g. Design and Construction History. Data relating to the design and construction were not available. According to the owner, the dam was constructed in 1913.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, and evaporation all combine to maintain a relatively stable water surface elevation.

1.3 PERTINENT DATA

a. Drainage Area - 451 acres

b. Discharge at Damsite.

(1) Discharge at the damsite is presently through an uncontrolled, unlined excavated trench at the left abutment.

(2) Prior to excavation of the trench, discharge was through a 12.5 feet wide chute spillway near the right abutment to a concrete box culvert beneath the Chouteau Trafficway.

(3) An 8-inch pipe is located beneath the crest of the chute spillway. The valve to the 8-inch pipe is inoperable.

(4) Estimated experienced maximum flood at damsite - Most recent on record was September 13, 1977. Discharge unknown, however the embankment experienced damage and sinkholes developed as reported by the Kansas City District, Corps of Engineers.

(5) Estimated ungated spillway and excavated trench capacity at maximum pool elevation 382 cfs (top of Dam El.828.3).

c. Elevation (Feet Above M.S.L.).

(1) Top of dam - 828.3 ± (see Plate 4)

(2) Emergency spillway crest - 826.4

(3) Excavated trench channel bottom - 823.5

(4) Streambed at toe of dam - 812.0 ±

(5) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 2,000 feet ± (includes pools above I-35)

(2) Length of normal pool - 1,000 feet ± (does not include pools above I-35)

e. Storage (Acre-feet).

(1) Top of dam - 106 (includes pools above I-35)

(2) Spillway crest - 67

(3) Excavated trench crest - 37

(4) Design surcharge - Not available.

f. Reservoir Surface (Acres).

(1) Top of dam - 17 (includes pools above I-35)

(2) Spillway crest - 10

(3) Excavated trench crest - 9.5

g. Dam.

(1) Type - Earth embankment

(2) Length - 900 feet

(3) Height - 20 feet ±

(4) Top width - 15 feet

(5) Side slopes - Varying. However, a section taken near the center of the embankment had an upstream face slope of 1.0 V on 3.0 H and downstream face slope of 1.0 V on 3.1 H.

(6) Zoning - Unknown.

(7) Impervious core - There is a possibility that the embankment has a concrete cutoff wall, however, this was not confirmed.

(8) Cutoff - Unknown.

(9) Grout curtain - Unknown.

h. Diversion and Regulating Tunnel - None.

i. Emergency Spillway.

(1) Type - Chute.

(2) Width of channel - 12.5 feet.

(3) Crest elevation - 826.4 feet m.s.l.

(4) Gates - None.

(5) Upstream channel - Not applicable.

(6) Downstream channel - The chute discharges to a 6 feet by 7 feet concrete box culvert beneath the Chouteau Trafficway near the toe of the downstream embankment slope.

j. Excavated Trench.

(1) Top width - 10.0 feet

(2) Bottom width - 9.0 feet

(3) Crest elevation - 823.5

(4) Downstream channel - The trench and downstream channel are unlined and eroding. Brush and tree roots are in the channel; a 12-inch clay pipe and 8-inch cast iron pipe, both reported by the City of Kansas City, Missouri as abandoned, cross the trench in an area that appears to be within the embankment material.

k. Regulating Outlets - None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data were unavailable.

2.2 CONSTRUCTION

Construction records were unavailable, however the owner estimated that the dam was built in 1913.

2.3 OPERATION

Failure of portions of the embankment occurred during the storm of September 1977. Emergency measures were taken at that time for lowering the lake level by excavating a trench at the left abutment to prevent further damage to the structure.

2.4 GEOLOGY

The dam is located in a valley formed in limestones and shales of the Kansas City Group. No outcrop of rock was observed in the area.

The soil at the site consists of the Wabash Silt Loam soil series, an alluvial soil deposited by overflow waters and colluvial washing of soils down valley slopes. It contains sand, silt, clay and is usually high in organic matter. For engineering purposes it is classified as silty clay (CL). The coarser grain sizes are more abundant near the streams. Gumbo and muck are normally present in small depressions.

2.5 EVALUATION

a. Availability. No engineering data could be obtained.

b. Adequacy. No engineering data were available upon which to make a detailed assessment of the design, construction, and operation. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Validity. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Winnetonka Lake Dam was made on 10 April 1979. The inspection team included professional engineers with experience in dam design and construction, hydrology - hydraulic engineering, and geotechnical engineering. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following items at the dam. The excavated ditch at the left abutment is extremely vulnerable to erosion due to the absence of adequate channel lining. Severe erosion of portions of the embankment crest and the upper portions of the embankment was noted. Areas of previous erosion and piping through the embankment have been filled with sand bags. These areas have been previously described as sinkholes in available inspection reports and field trip memorandum. One area was described by the Kansas City District, Corps of Engineers as an 8-foot diameter hole extending from the crest to a 2-foot diameter hole at the downstream slope approximately 8 feet below the crest prior to backfilling with sandbags. Inadequate drainage of the area downstream of the toe of the embankment was observed. Riprap on the upstream face is for the most part beneath the water level. On the downstream slope erosion has occurred at the excavated trench and along the downstream toe of the embankment. The downstream face is covered with a heavy growth of brush and trees, some of which were observed to be dead. Severe sloughing was observed on the downstream embankment slope.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. A concrete chute spillway which was constructed near the right abutment is undermined apparently due to overtopping of the embankment adjacent to the spillway (see Photo 14). There is evidence of repair to the chute slab and walls. The base of the spillway is concrete with concrete walls approximately 6 inches thick. No seepage was observed at or near the chute spillway. An 8-inch diameter pipe protrudes from the chute slab approximately 2 feet below the chute spillway crest with an inoperable valve at the upstream end. The inlet to the pipe could not be observed. The pipe is steel and appears to be in good condition. No seepage or discharge was observed from or near the pipe interface with the chute slab or outlet. An abandoned spillway located in proximity to the present emergency spillway has been undermined. The spillway has been filled with debris, silts, and clays typical of the embankment. Severe erosion beneath the abandoned spillway has cut deeply into the embankment material (see Photo 15). The potential for piping and seepage exists

beneath the abandoned spillway, although none was observed at this location at the time of inspection. A ditch excavated at the left abutment serves to control the lake level at this time and is addressed in section 3.1b.

d. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir.

e. Downstream Channel. The spillway discharges to a concrete box culvert beneath the Chouteau Trafficway. The trench at the left abutment discharges to an unprotected channel near the toe of the downstream embankment slope.

3.2 EVALUATION

The visual inspection of this dam resulted in a notification being given to the St. Louis District, Corps of Engineers that the safety of the dam was questionable. Numerous conditions were observed by the inspection party which in their opinion are severe enough to warrant immediate attention and future monitoring and analyses.

Particular attention should be focused on the lack of remedial maintenance or reconstruction of those areas of the dam exhibiting failure. The relatively large sand bagged area should be repaired (see Photos 16 and 17 and Plate 6). Removal of sand bags and replacement with compacted fill is warranted. Erosion ditches and holes in proximity to the emergency spillway appear to be severe enough that, in the event the lake level reaches spillway elevation, the integrity of the embankment near the spillway would be in jeopardy. Similarly, the large washout beneath the abandoned spillway, immediately to the east of the present emergency spillway, is in need of repair. The stability condition of the embankment material remaining between this hole and the upstream face was not evaluated. A serious potential for a washout failure exists in the event the lake level is allowed to rise toward the top of the dam.

Numerous trees and brush have been allowed to grow on both the upstream and downstream slopes and along the dam crest. The development of root systems in the embankment material produces a potential source for future problems. Decay of roots provides possible avenues for leakage/seepage. The extent of possible root decay, leakage, etc. could not be evaluated from the visual inspection. However, the potential for such sources of failure exist at this dam and could possibly be extensive.

The excavated trench near the left abutment provides the path for normal discharge. As reported by the Kansas City District, Corps of Engineers, this emergency measure was taken in September 1977 as a means

to lower the impounded water surface and thereby reduce the potential for failure. The unlined trench is eroding embankment material along its length. Undercutting of the dam embankment material near the toe of the slope has taken place because of this emergency measure. Tree roots have been washed of surrounding soil and apparently have provided points for deflecting the discharge water into the embankment. The extent of damage resulting from this unlined trench could not be fully assessed.

The apparent lack of drainage between the downstream toe of the dam and the Chouteau Trafficway is believed to be a contributing factor in the formation of swampy conditions. The effects of the observed moisture conditions on the stability of the embankment foundation need to be evaluated following acquisition of insitu data.

Due to the extreme irregularity of the embankment slopes, crest, and the excessive rubble, debris, and brush present on the embankment, observations and subsequent evaluation of cracking, settlement, and sloughing of the embankment was unfeasible.

The visible lack of maintenance, coupled with the age of this structure, leads the inspection crew to the conclusion that further study is warranted. Substantiation of the existence of a cutoff wall would possibly provide justification for reducing the interpreted seriousness of the potential for a failure at this dam. However, even though it may be found that a wall does exist, its presence should not preclude the development and implementation of a systematic, well engineered repair and maintenance program.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool was primarily controlled by rainfall, runoff, evaporation, and capacity of the uncontrolled chute spillway prior to lowering the lake level. Following the excavation of the trench, the reservoir level is controlled also by the capacity of the excavated trench.

4.2 MAINTENANCE OF DAM

There is an apparent lack of maintenance at this dam.

4.3 MAINTENANCE OF OPERATING FACILITIES

A valve located at the 8-inch diameter steel pipe passing from the upstream face of the embankment through the downstream spillway apron was observed and, as reported by the Kansas City District, Corps of Engineers, was inoperable.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection team is not aware of any existing warning system for this dam.

4.5 EVALUATION

The absence of maintenance has proved to be detrimental to the embankment. The lack of slope protection on the upstream face and proper vegetal cover on the downstream face have contributed to the erosion observed. Deterioration of the embankment following heavy rains in September 1977 may also be attributed to the lack of maintenance of the embankment and appurtenant structures.

There is evidence that repairs have been made to the concrete apron and walls of the spillway, however, the spillway is severely undermined along the downstream slope. It is apparent after observing conditions of severe erosion, heavy growth of trees and brush, and random temporary repairs that the embankment has received little or no maintenance in recent years. Subsequent to heavy rains on September 12 and 13, 1977 and the resulting damage to the embankment, volunteers under supervision of the Kansas City District, Corps of Engineers placed about 800 sandbags in a hole located in the upstream embankment to prevent further deterioration and later on September 14, 1977 excavated an 8 foot deep by 8 foot wide ditch at the left abutment, as reported by the Kansas City District, Corps of Engineers. The trench has since eroded severely because of the lack of adequate channel protection.

A comprehensive operation, repair, and maintenance program should be developed and implemented for Winnetonka Dam. Until such time when a program has eliminated or relieved the seriousness of the noted visible deficiencies, continuous monitoring of this dam during stress periods is in order.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data pertaining to hydrology and hydraulics were unavailable.

b. Experience Data. The drainage area and lake surface area are developed from USGS North Kansas City, Missouri-Kansas Quadrangle Map. The spillway and dam layouts are from surveys made during the inspection.

c. Visual Observations.

(1) An emergency spillway is located near the right abutment and is generally in fair condition. Its walls and apron have spalling and some small cracks. The concrete apron for the spillway is being undermined. Spillway discharges enter a box culvert beneath Chouteau Trafficway. There is no defined approach channel to the spillway.

(2) An 8-inch steel pipe, possibly used at sometime for drawing down the water surface, remains in place. The Kansas City District, Corps of Engineers reports that the valve for the pipe is inoperable, that the inlet could not be located and the pipe cannot be used to drawdown to pool.

(3) A trench has been excavated near the left abutment for the expressed purpose of lowering the pool level. This action was accomplished on September 14, 1977 as reported by the Kansas City District, Corps of Engineers. The absence of channel protection in the trench has led to erosion within the trench and embankment.

(4) An abandoned spillway was observed in the vicinity of the existing emergency spillway. It is a non-functioning appurtenance.

d. Overtopping Potential. The spillway and trench operating together will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway and trench will pass 20 percent of the probable maximum flood and the 100-year flood without overtopping the dam. The distribution for the 100-year rainfall was provided by the St. Louis District, Corps of Engineers. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the small volume of water impounded and the downstream hazard, 50 percent of the probable maximum flood is

the appropriate spillway design flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 4,300 cfs of the total discharge from the reservoir of 4,900 cfs. The estimated duration of overtopping is 7.7 hours with a maximum height of 1.3 feet. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 1,800 cfs of the total discharge of the reservoir of 2,300 cfs. The estimated duration of overtopping is 5.3 hours with a maximum depth of 0.7 feet over the dam. Failure of two small upstream water impoundments shown on the 1970 revised USGS map would not have a significant impact on the hydrologic or hydraulic analysis. In the unlikely event of the failure of the I-35 embankment, Lake Winnetonka would suffer severe damage.

Subsequent hydraulic analyses were performed without including the excavated trench. Discharge from the reservoir was through the spillway and over the top of the embankment. The spillway in this case will pass neither 10 percent of the probable maximum flood nor the 100-year flood without overtopping the dam.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately 1 mile downstream of the dam. The inspection team noted that there are more than four homes, commercial buildings, a grade school, State Highway 269, and the Chouteau Trafficway downstream of the dam which could be severely damaged and lives could be lost should failure of the dam occur.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Detailed seepage and stability analysis should be performed as required by the guidelines.

c. Operating Records. No operational records exist.

d. Post Construction Changes. A spillway located in the right one-third of the dam has been abandoned and filled and a newer spillway constructed near the right abutment.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone.

Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the recent inspection should be corrected immediately and several require monitoring and/or control. The integrity of the Winnetonka Dam apparently has been jeopardized because of the lack of maintenance. Conditions warranting immediate attention are those which, if allowed to remain as observed, increase the potential for failure. The following measures should be implemented in the immediate future:

(1) The relatively large hole under the abandoned spillway should be filled.

(2) Erosion gullies, holes, and sinks in vicinity of emergency spillway should be located and returned to a stable condition.

(3) The existing failure zone that was repaired with sandbags should be repaired.

(4) The excavated trench near the left abutment should be provided with riprap protection.

Monitoring and control of less critical conditions is warranted. Such conditions are:

(1) Riprap protection should be provided along the entire upstream face of this dam.

(2) Growth of trees and brush should be controlled.

(3) The area immediately downstream of the dam should be provided with an adequate drainage system.

(4) A program for locating sinkholes developing on this structure is warranted.

b. Adequacy of Information. Due to the lack of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. However, seepage and stability analyses are needed to satisfy the requirements of the guidelines.

c. Urgency. It is the opinion of the inspection team that a program should be developed as soon as possible to implement remedial measures recommended in paragraph 7.2b. If the safety deficiencies

listed in paragraph 7.1a are not corrected, they will continue to deteriorate and lead to a more serious potential of failure. Immediate precautionary measures should be taken to preclude serious damage and possible failure of the embankment in the event of heavy rains over the drainage area.

d. Necessity for Phase II. The Phase I investigation raises serious questions relating to the safety of the dam.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment was not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Immediate Measures. Additional inspection and evaluation of the embankment has been performed by the State of Missouri and the St. Louis District, Corps of Engineers subsequent to notice that the embankment would be in danger of failure should the lake level be allowed to increase. Further rising of the lake level and possible overtopping due to low discharge capacities of the spillway and trench could cause severe erosion of the embankment because of the lack of slope protection and inadequate repair of previous points of failure in the embankment. Furthermore, the following measures should be undertaken immediately under the direction of an engineer experienced in the design, construction, repair, and maintenance of earth embankment dams to correct items observed by the inspection team:

(1) Provide channel protection for the trench at the left abutment.

(2) Investigate and repair undermining of the downstream toe of the embankment which may be attributed to discharge from the trench at the left abutment.

(3) Investigate the causes for failure of portions of the embankment observed subsequent to heavy rains in September 1977. This investigation should include but not be limited to the two large holes or sinkholes eroded in the embankment which were filled with sandbags as temporary repair, erosion and undermining of the spillway, and the cavern-like hole beneath the abandoned spillway for which no repairs have been made.

(4) Investigate the adequacy of drainage near the downstream toe of the embankment and the threat of increased saturation of embankment material on the downstream face.

(5) Repair those items found deficient as determined by evaluation of investigative results.

b. Alternatives. The present spillway and excavated trench have the capacity to pass 20 percent of the probable maximum flood without overtopping the dam. In order to pass 50 to 100 percent of the probable maximum flood as required by the Recommended Guidelines, the spillway size and/or height of dam would need to be increased.

A viable alternative which would totally eliminate the need for expensive repairs, continuous monitoring during periods of stress, and would alleviate the reported concerns of downstream inhabitants is the draining of the lake. Although this alternative is most drastic, it may well be the most realistic, most cost-effective and understandably would offer the greatest degree of safety.

c. O&M Maintenance and Procedures. The following O&M maintenance and procedures are recommended subsequent to implementation of the immediate measures outlined in paragraph 7.2a or if the lake draining alternative is not acceptable:

(1) Check the downstream face of the dam periodically for seepage and stability problems. If seepage flows are observed or sloughing on the downstream embankment slope is noted, the dam should immediately be inspected and the condition evaluated by an engineer experienced in design and construction of earthen dams.

(2) Due to the density and large size of the trees on the downstream slope of the dam, an engineer experienced in the maintenance and design of earthen dams should be retained to recommend procedures to control the growth of the trees and establish proper slope protection.

(3) Erosion protection should be added on the upstream slope. This protection is needed to prevent erosion of the embankment material due to wave action.

(4) Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of dams.

(5) A detailed inspection of the dam should be made periodically by an engineer experienced in design and construction of dams. More frequent inspections should be required if the noted deficiencies are not repaired or if additional deficiencies are observed.

(6) Continuous monitoring of the facility during periods of stress brought on by rainfall should be provided to assure adequate warning of possible overtopping or failure.

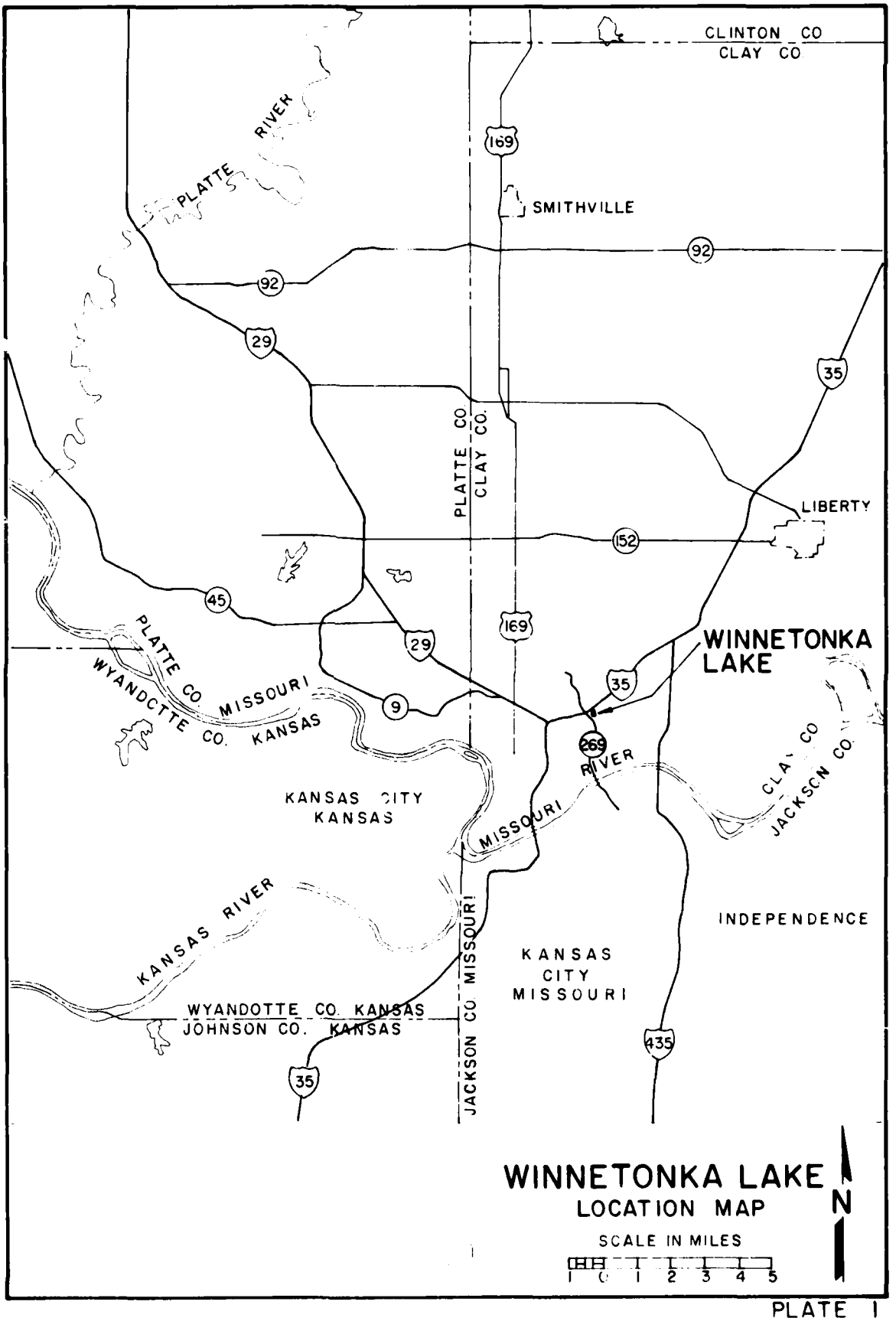

CLINTON CO
CLAY CO
PLATTE RIVER
PLATTE
169
SMITHVILLE
92
92
29
35
PLATTE CO.
CLAY CO.
LIBERTY
152
45
169
29
WINNETONKA
LAKE
PLATTE CO. MISSOURI
WYANDOTTE CO. KANSAS
9
35
269
KANSAS CITY
KANSAS
MISSOURI RIVER
CLAY CO
JACKSON CO.
KANSAS RIVER
INDEPENDENCE
JACKSON CO MISSOURI
KANSAS
CITY
MISSOURI
WYANDOTTE CO. KANSAS
JOHNSON CO. KANSAS
435
35
WINNETONKA LAKE
LOCATION MAP
SCALE IN MILES
1 0 1 2 3 4 5
N

PLATE 1

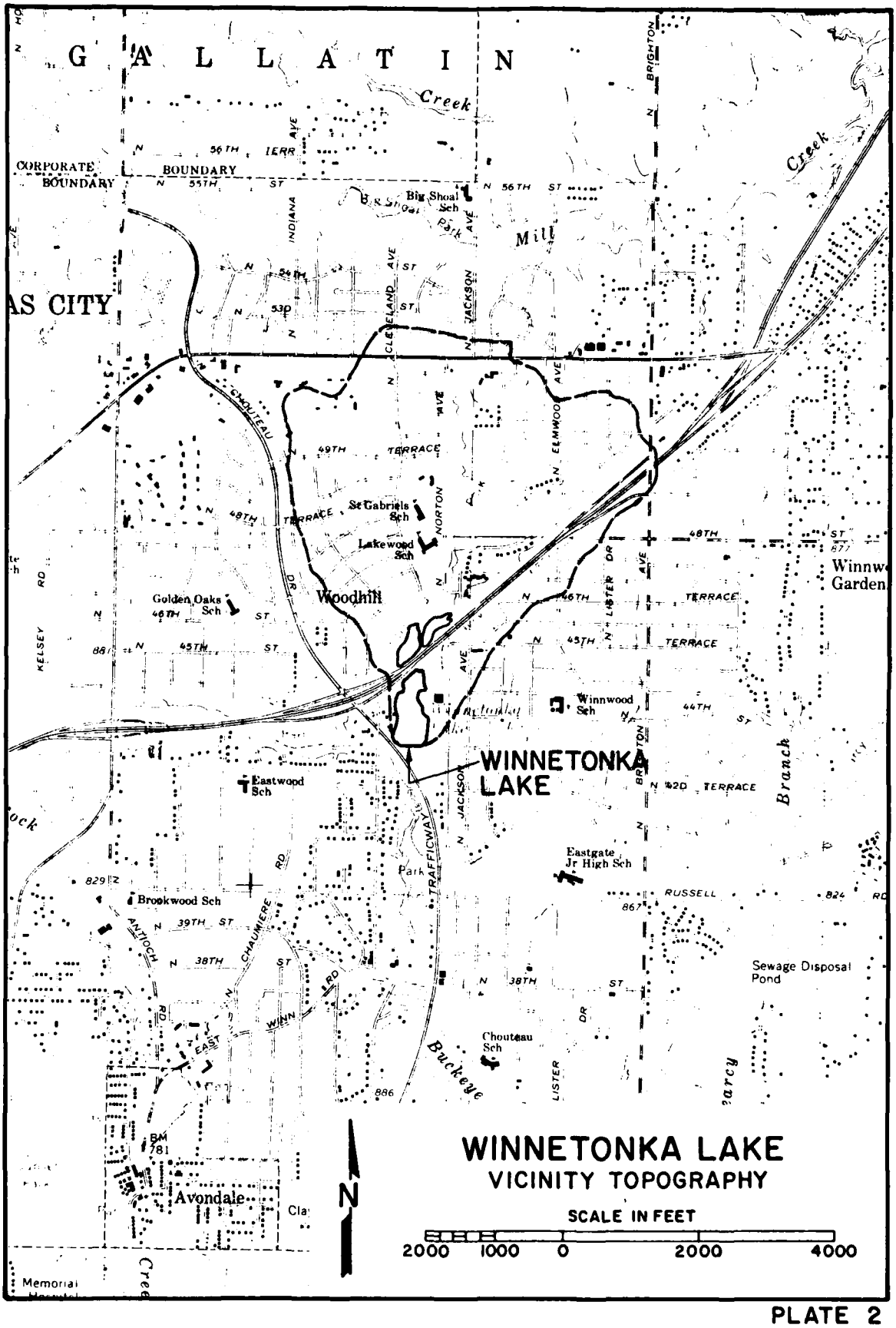
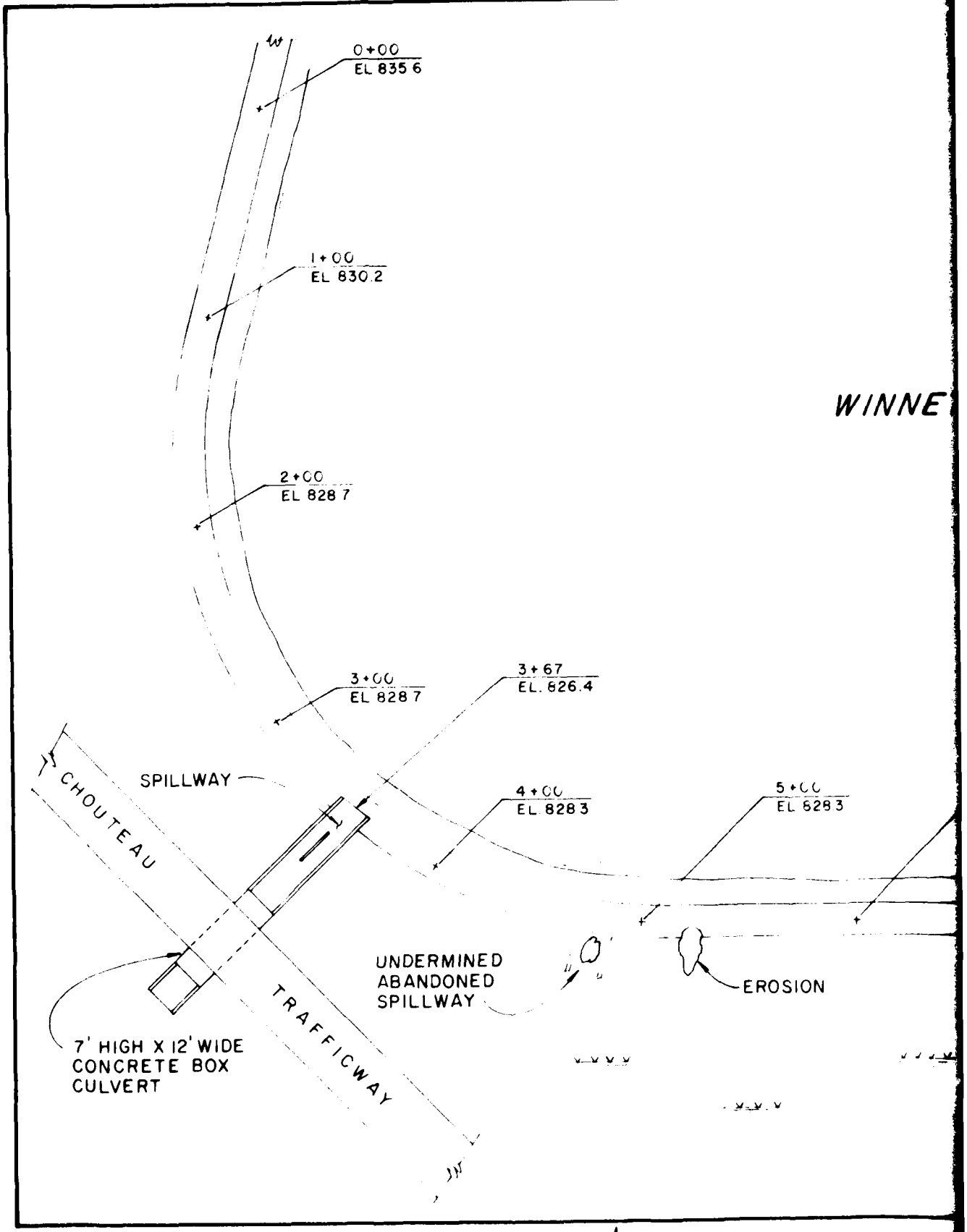
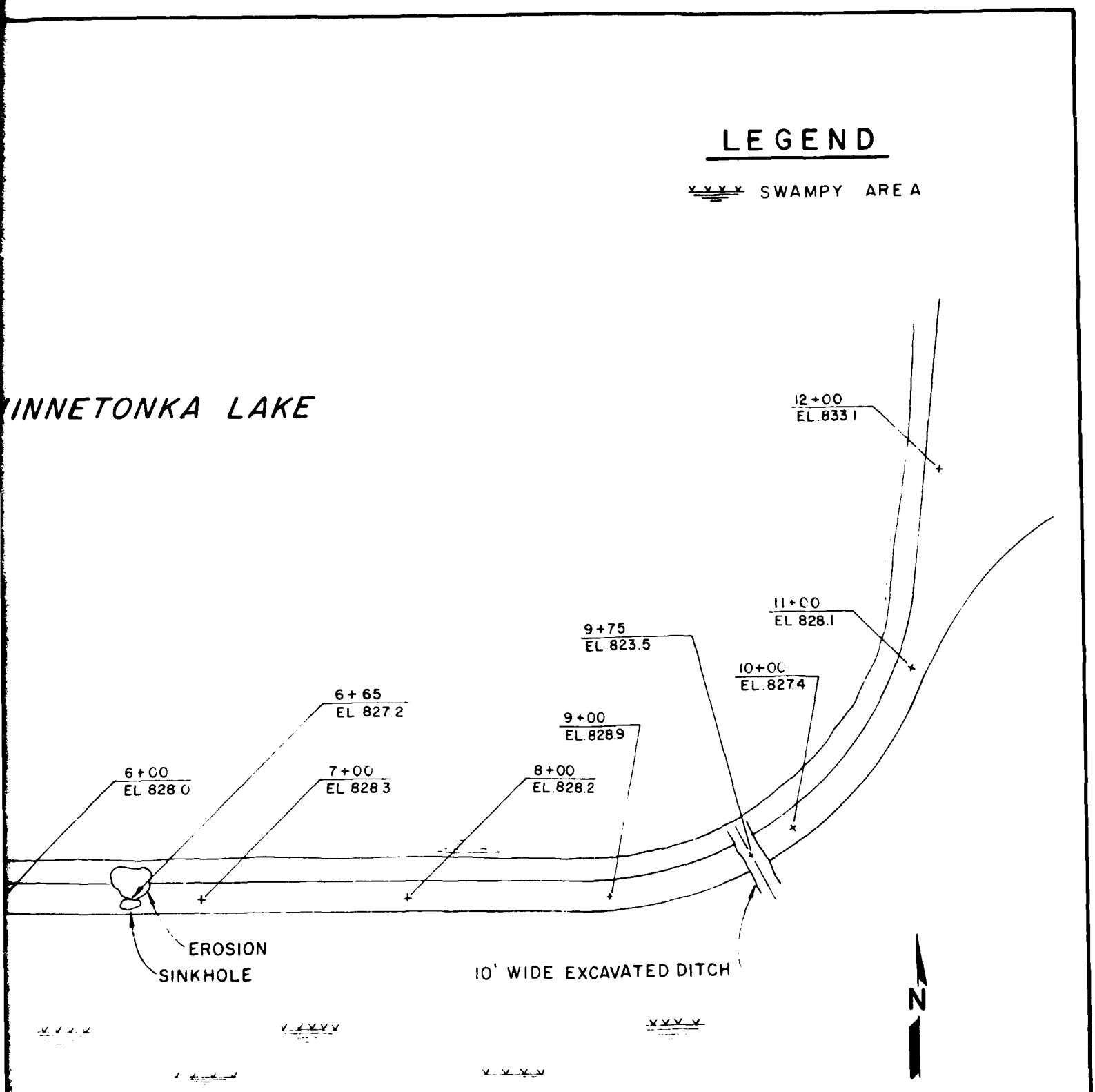

G A L L A T I N
Creek
CORPORATE BOUNDARY
BOUNDARY
AS CITY
Big Shoal Sch
Mill
Woodhill
St Gabriels Sch
Lakewood Sch
Golden Oaks Sch
Winnwood Sch
WINNETONKA LAKE
Eastwood Sch
Eastgate Jr High Sch
Brookwood Sch
Sewage Disposal Pond
Chouteau Sch
Avondale
Memorial
Branch
Buckeye
N
WINNETONKA LAKE
VICINITY TOPOGRAPHY
SCALE IN FEET
2000 1000 0 2000 4000

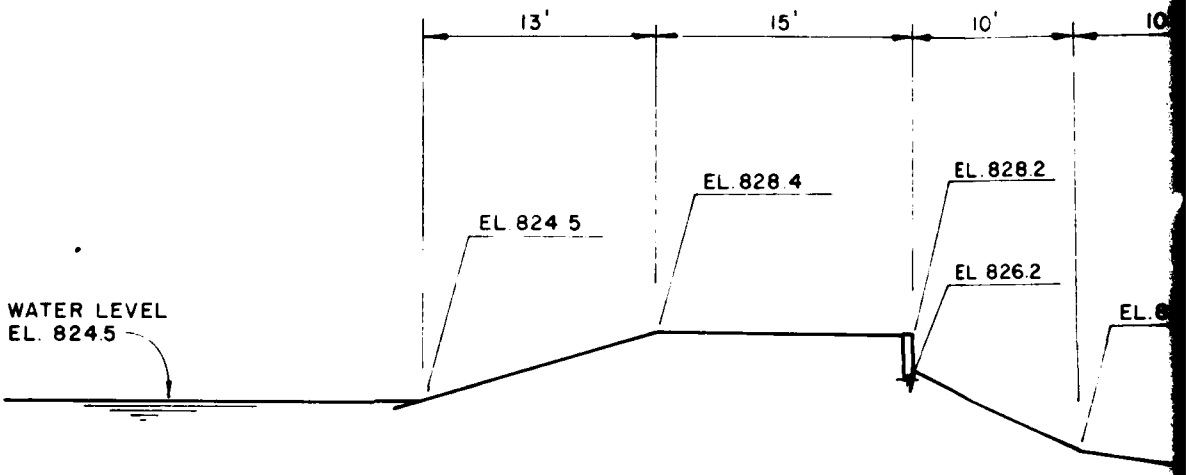
PLATE 2


0+00
EL 835 6
1+00
EL 830.2
2+00
EL 828 7
3+00
EL 828 7
3+67
EL. 826.4
4+00
EL 828 3
5+00
EL 828 3
SPILLWAY
CHOUTEAU
TRAFFICWAY
UNDERMINED
ABANDONED
SPILLWAY
EROSION
7' HIGH X 12' WIDE
CONCRETE BOX
CULVERT

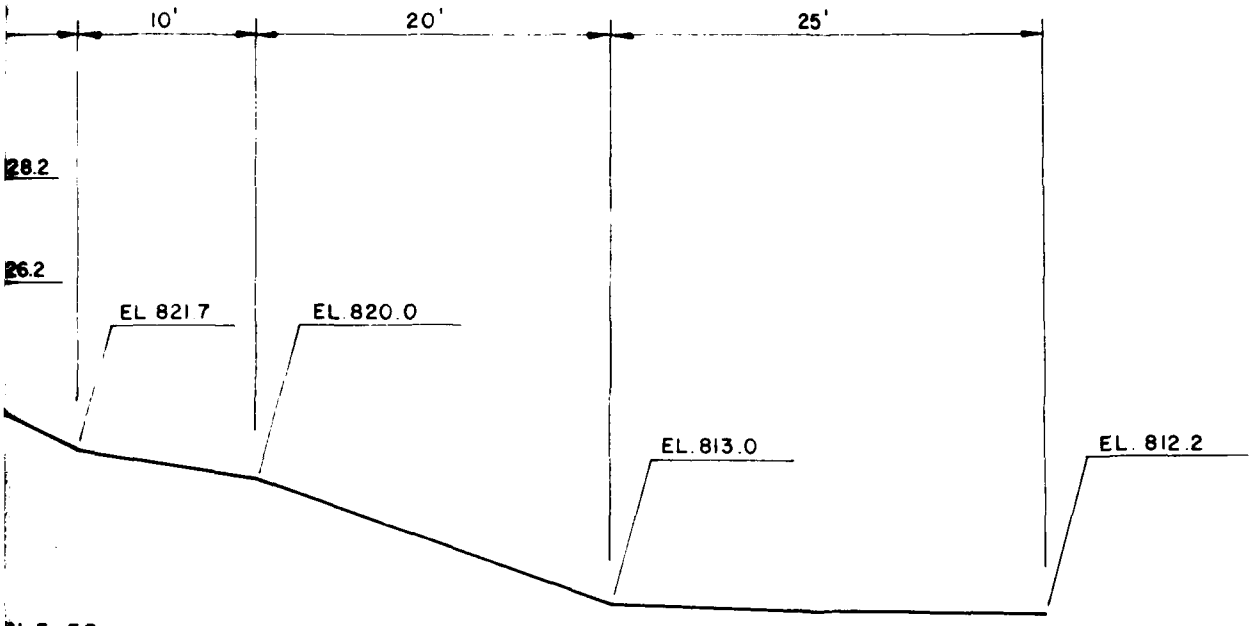


WINNETONKA LAKE
PLAN

PLATE



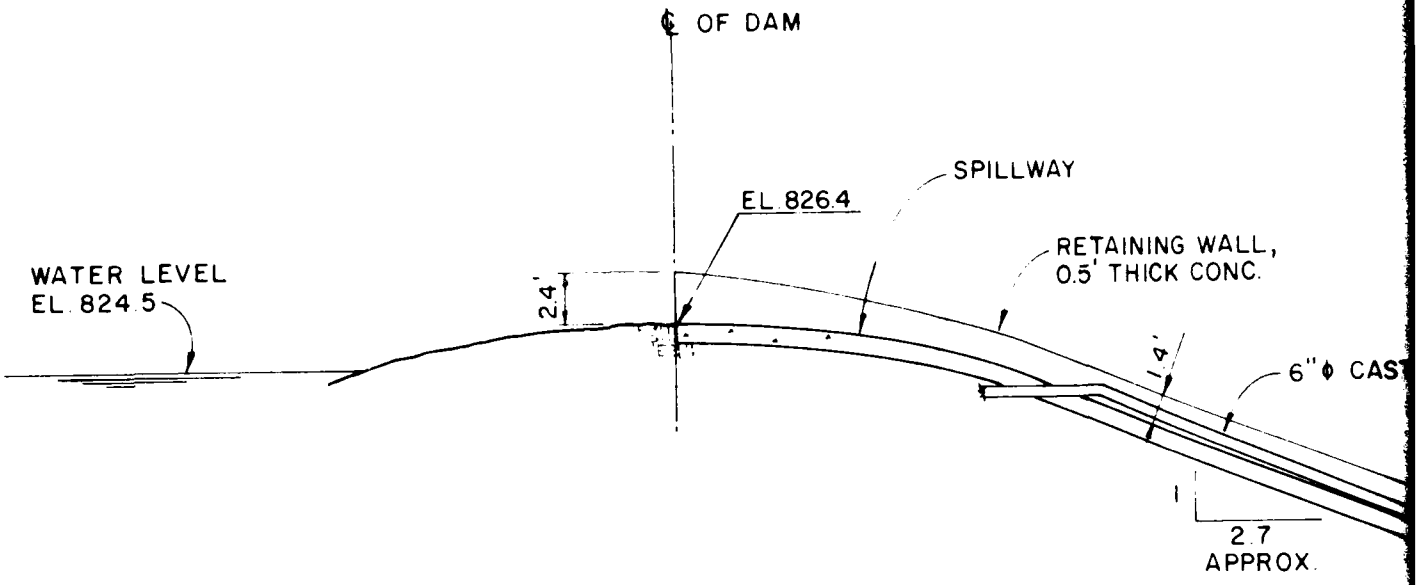
NOTE: THIS SECTION TAKEN AT STATION 5+50 IS TYPICAL, BUT DAM VARIES SOMEWHAT OVER IT'S LENGTH



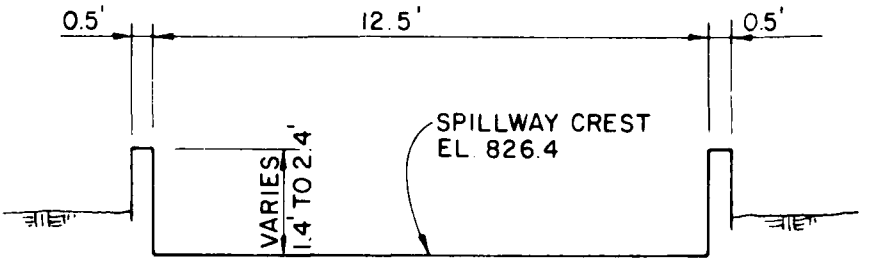
N 5+50
MEWHAT

WINNETONKA LAKE
TYPICAL SECTION

PLATE 4

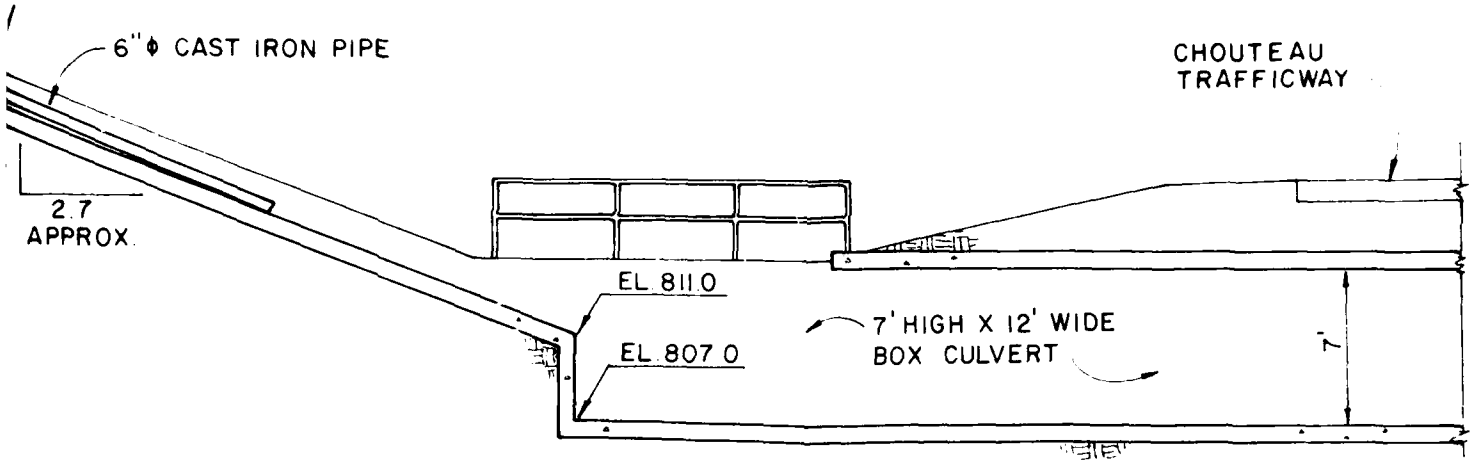


SPILLWAY LONGITU



SPILLWAY CROSS SECTION

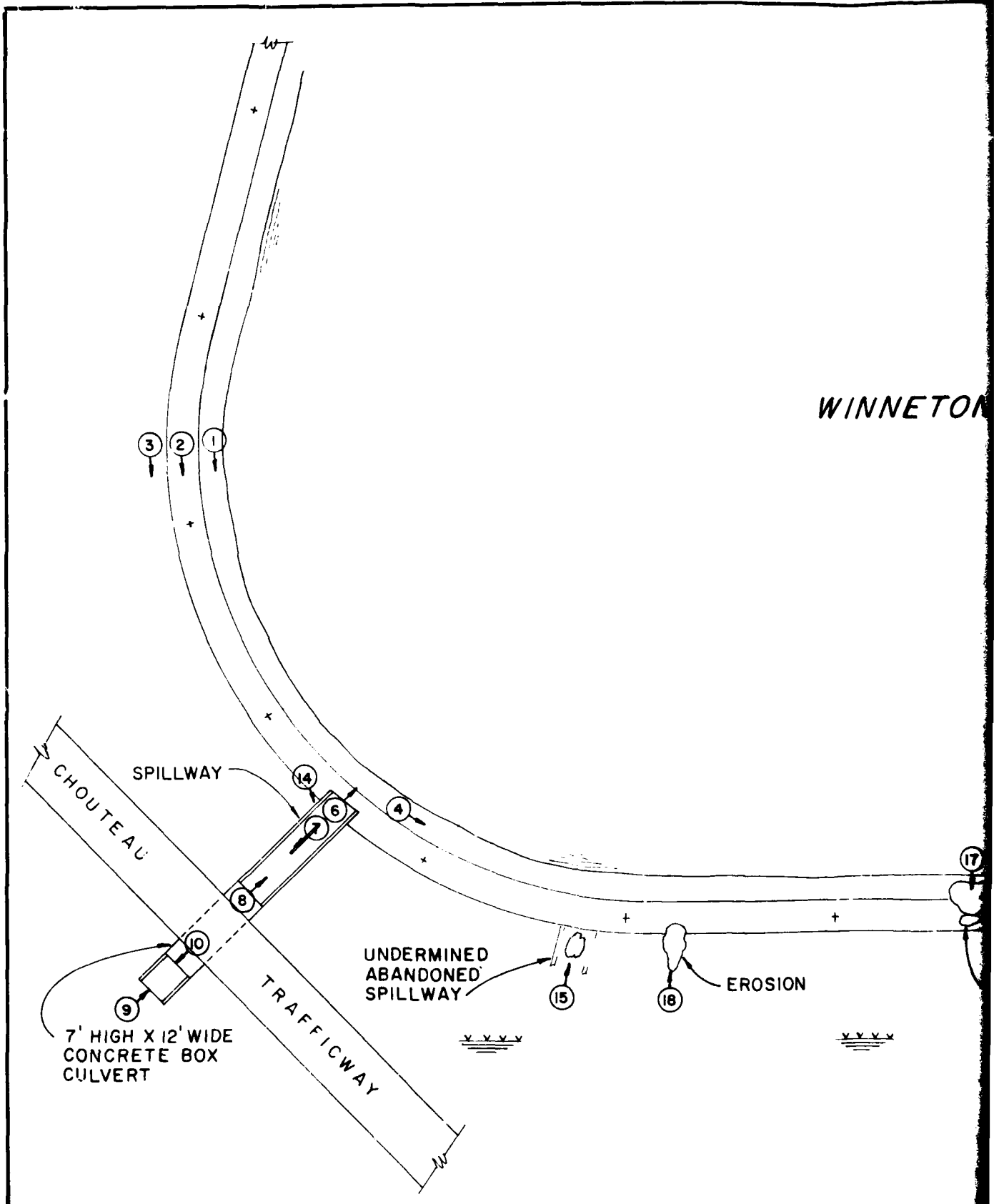
WALL,
CONC.

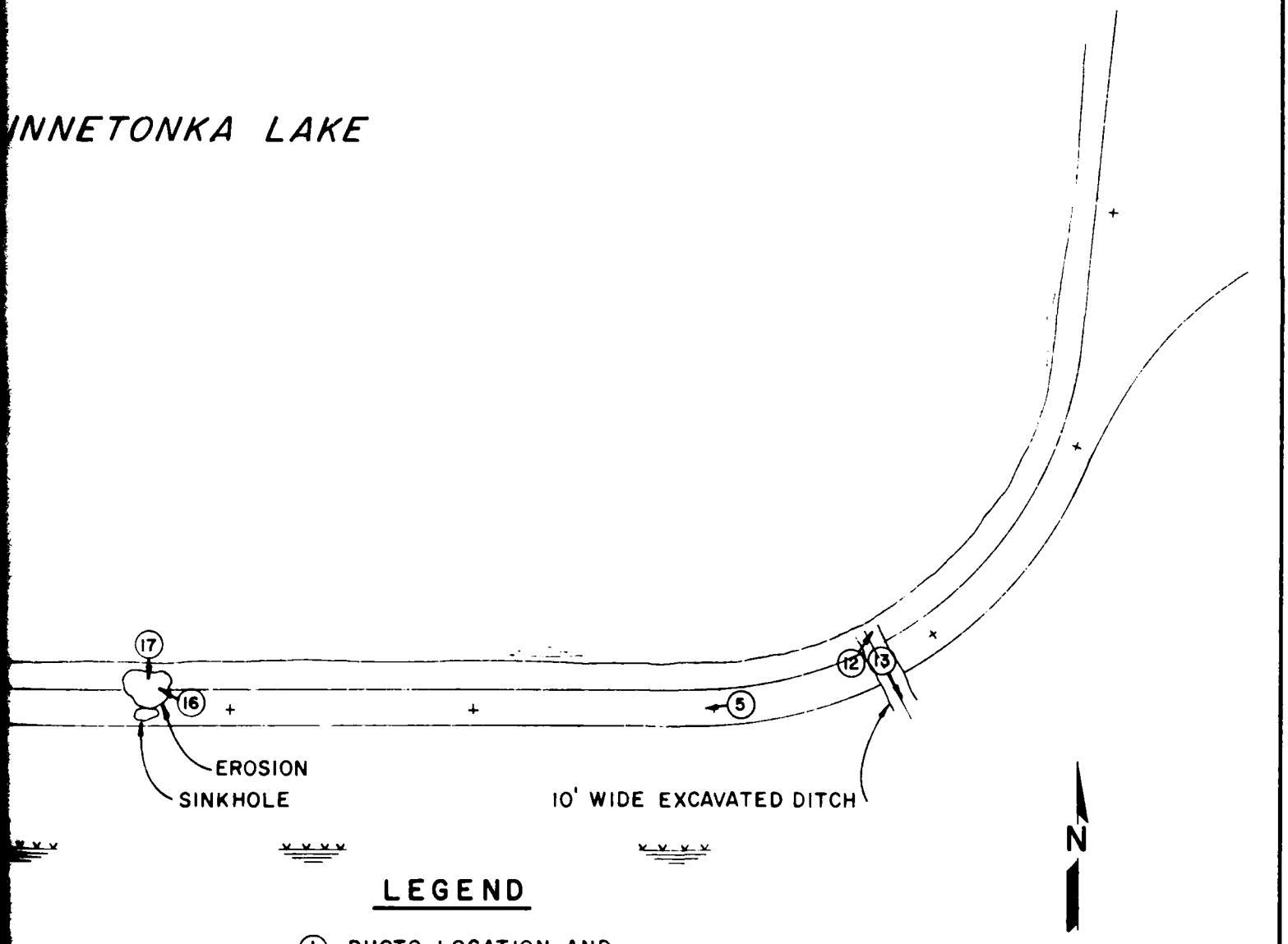


AY LONGITUDINAL SECTION

WINNETONKA LAKE
SPILLWAY SECTIONS

PLATE 5


WINNETON
3
2
1
SPILLWAY
14
6
7
4
CHOUTEAU
8
17
10
9
7' HIGH X 12' WIDE
CONCRETE BOX
CULVERT
TRAFFICWAY
UNDERMINED
ABANDONED
SPILLWAY
15
18
EROSION



LEGEND

(1) PHOTO LOCATION AND DIRECTION

SWAMPY AREA

WINNETONKA LAKE PHOTO INDEX

PLATE 6

PHOTO 1: UPSTREAM FACE OF DAM NEAR WEST ABUTMENT

PHOTO 2: CREST OF DAM NEAR WEST ABUTMENT

PHOTO 3: DOWNSTREAM SLOPE OF DAM NEAR WEST ABUTMENT

PHOTO 4: UPSTREAM FACE OF DAM LOOKING EAST

PHOTO 5: CREST OF DAM LOOKING WEST

PHOTO 6: SPILLWAY LOOKING UPSTREAM FROM CREST

PHOTO 7: SPILLWAY LOOKING DOWNSTREAM FROM CREST

PHOTO 8: SPILLWAY CHUTE

PHOTO 9: CULVERT UNDER CHOUTEAU TRAFFICWAY BELOW SPILLWAY

PHOTO 10: CHANNEL BELOW CHOUTEAU TRAFFICWAY

PHOTO 11: DOWNSTREAM CHANNEL

PHOTO 12: DITCH AT EAST ABUTMENT LOOKING UPSTREAM

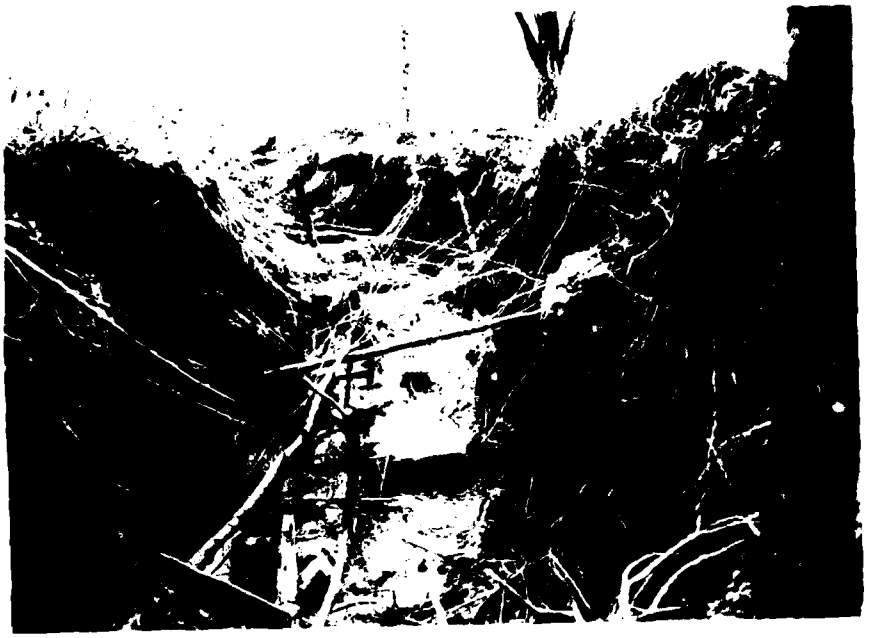


PHOTO 13: DITCH AT EAST ABUTMENT LOOKING DOWNSTREAM

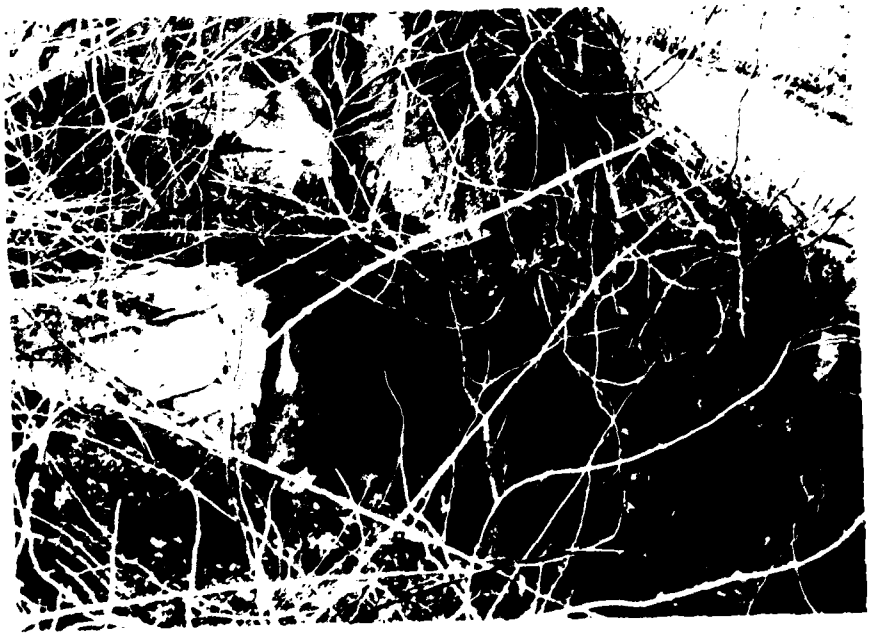


PHOTO 14: UNDERMINING OF SPILLWAY AT TOP OF DOWNSTREAM SLOPE

PHOTO 15: UNDERMINING OF ABANDONED SPILLWAY AT DOWNSTREAM SLOPE

PHOTO 16: SINKHOLE IN UPSTREAM FACE OF DAM

PHOTO 17: SINKHOLE IN UPSTREAM FACE AND EROSION OF CREST

PHOTO 18: EROSION OF DOWNSTREAM SLOPE

APPENDIX A

HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph and HEC-1 (1) were used to develop the inflow hydrographs, and hydrologic inputs are as follows:

a. Twenty-four hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33.

200 square mile, 24 hour rainfall inches	- 24.5
10 square mile, 6 hour percent of 24 hour 200 square mile rainfall	- 101%
10 square mile, 12 hour percent of 24 hour 200 square mile rainfall	- 120%
10 square mile, 24 hour percent of 24 hour 200 square mile, rainfall	- 130%

b. Drainage area = 451 acres.

c. Time of concentration:

$Tc = (1.67)\ L$

$$L = \frac{\ell^{0.8}(S+1)^{0.7}}{1{,}900\ Y^{0.5}}$$

L = lag in hours

ℓ = hydraulic length of watershed in feet

$S = \frac{1{,}000}{CN} - 10$ (where CN is the retardance factor and is equivalent to the runoff curve number)

Y = average watershed land slope in percent

Tc = 0.75 hours (above I-35) and 0.36 hours (below I-35) (2).

d. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 92 and antecedent moisture condition III. The hydrologic soil group in the basin was B.

e. Inflows for the 100-year flood were determined from the 24-hour, 100-year rainfall distribution for drainage areas less than one square mile provided by the St. Louis District, Corps of Engineers. Losses for

the 100-year event were determined in accordance with SCS methods for determining runoff using a curve number of 81 and antecedent moisture condition II.

2. Discharge rates through the chute spillway are based on the broad-crested weir equation.

Broad-crested weir equation:

$Q = CLH^{1.5}$ (C = 4.0, L = 12.5 feet, H is the head on weir).

Discharge rates through the excavated trench, assuming a supercritical slope in the channel, are based on the broad-crested weir equation also.

$Q = CLH^{1.5}$ (C = 2.63, L = 9.0 feet)

Discharge rates over the top of the dam are also based on the broad-crested weir equation:

$Q = CLH^{1.5}$ (C = 3.1, L = 970 feet).

3. The elevation-storage relationship above normal pool elevation was constructed by planimetering the area enclosed within each contour above normal pool. The storage between two elevations was computed by multiplying the average of the areas at the two elevations by the elevation difference. The summation of these increments below a given elevation is the storage below that level.

4. Inflows to the ponding area above Interstate 35 are routed through the 6 foot by 7 foot concrete box culvert. The 24-inch pipe beneath I-35 was blocked at the time of inspection, thus was not used in the analysis. The outflow hydrographs of the box culvert are combined with inflows generated from the watershed below Interstate 35. Subsequently, the combined hydrographs are routed through the spillway using HEC-1, modified Puls to determine the capability of the spillway.

(1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.

(2) U.S. Department of Agriculture, Soil Conservation Service, Urban Hydrology for Small Watersheds, January 1975, GPO.

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  25 SEP 78
**********
     1                A1MISSOURI DAM INSPECTION PROGRAM
     2                A2ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
     3                A3WINNETONKA LAKE DAM NO 1 10 11
     4                B    288         0         5         0         0         0         0         0         0         0         0
     5                B1     5
     6                J      1         9         1
     7                J1   .10      .15       .20       .25       .30       .35       .40       .50      1.0
     8                K      0         1                                      3         1
     9                K1   24 HR PMF INFLOW ABOVE I35
    10                M      1         2       .61                            1
    11                P              24.5      101       120       130
    12                T                                                                -1       -92
    13                W2              .45
    14                X                         1
    15                K      1         2                                                1
    16                K1   ROUTE THROUGH CULVERT UNDER I35
    17                Y                                   1         1
    18                Y1     1                                                         -1        -1
    19                Y4 828.06 830.16  830.86  832.26  835.06  838.31  838.56  842.06
    20                Y5     0        54        84       156       325       498       516       660
    21                $A 5.5    8.3      18.4     28.5
    22                $E 828.05 830.     840.     850.
    23                $$ 828.06
    24                $D 838.3 13.1      1.5      500.
    25                K      0         3                                      3         1
    26                K1   24 HR PMF INFLOW TO LAKE WINNETONKA BELOW I35
    27                M      1         2       .1                             1
    28                P              24.5      101       120       130
    29                T                                                                -1       -92
    30                W2              .21
    31                X                         1
    32                K      2         4                                                1
    33                K1   COMBINE HYDROGRAPHS
    34                K      1         5                                                1
    35                K1   ROUTE THROUGH WINNETONKA LAKE DAM AND SPILLWAY
    36                Y                                   1         1
    37                Y1     1                                                         -1        -1
    38                Y4 823.5  824.     825.     826.     826.41   827.     828.     829.     830.
    39                Y5 0.     8.       43.      94.      117.     178.     326.     513.     732.
    40                $A    9.5     13.3     17.9
    41                $E 823.5  830.     840.
    42                $$ 823.5
    43                $D 828.3  13.1     1.5      970.
    44                K     99
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

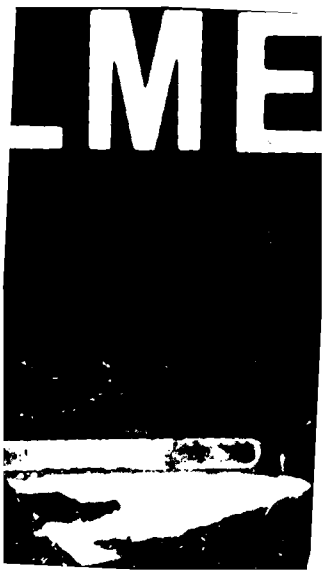
OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .10	RATIO 2 .15	RATIO 3 .20	RATIO 4 .25	RATIO 5 .30	RATIO 6 .35	RATIO 7 .40	RATIO 8 .50	RATIO 9 1.00
HYDROGRAPH AT	1	.61	1	452.	678.	904.	1130.	1355.	1581.	1807.	2259.	4518.
		(1.58)		(12.79)	(19.19)	(25.59)	(31.98)	(38.38)	(44.78)	(51.17)	(63.97)	(127.94)
ROUTED TO	2	.61	1	183.	277.	358.	430.	496.	975.	1492.	2122.	4414.
		(1.58)		(5.17)	(7.85)	(10.15)	(12.17)	(14.06)	(27.62)	(40.83)	(60.09)	(125.00)
HYDROGRAPH AT	3	.10	1	106.	160.	213.	266.	319.	372.	426.	532.	1064.
		(.26)		(3.01)	(4.52)	(6.03)	(7.53)	(9.04)	(10.54)	(12.05)	(15.06)	(30.13)
2 COMBINED	4	.71	1	210.	323.	436.	544.	648.	1066.	1571.	2363.	4911.
		(1.84)		(5.96)	(9.14)	(12.34)	(15.39)	(18.34)	(30.17)	(44.49)	(66.93)	(139.06)
ROUTED TO	5	.71	1	162.	272.	369.	485.	563.	1042.	1534.	2337.	4914.
		(1.84)		(4.58)	(7.71)	(10.46)	(13.73)	(15.95)	(29.51)	(43.43)	(66.19)	(139.15)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	823.50	823.50	828.30
STORAGE	0.	0.	52.
OUTFLOW	0.	0.	382.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	826.84	0.00	35.	162.	0.00	18.33	0.00
.15	827.64	0.00	44.	272.	0.00	18.00	0.00
.20	828.23	0.00	51.	369.	0.00	17.83	0.00
.25	828.39	.09	53.	485.	2.50	16.92	0.00
.30	828.44	.14	54.	563.	3.58	16.92	0.00
.35	828.64	.34	58.	1042.	3.92	16.50	0.00
.40	828.80	.50	58.	1534.	4.33	16.33	0.00
.50	829.01	.71	61.	2337.	5.33	16.17	0.00
1.00	829.56	1.26	68.	4914.	7.67	16.08	0.00


LME